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PRELIMINARY DATA COMPILATION FOR SELECTED DRAINAGE BASINS IN NOVA SCOTIA FOR A *LOW FLOW* REGIONAL ANALYSIS STUDY

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1. INTRODUCTION

During the summer of 1985, the collection of data concerning certain physiographic characteristics of selected river drainage basins in Nova Scotia was undertaken for a regional low flow study by the Inland Waters Directorate, Environment Canada, in Dartmouth, Nova Scotia. The data base was determined to see if a correlation exists between these physiographic parameters and recorded low flows for the basins examined. If it is seen that a correlation does exist, then it would make possible the prediction of low flows for both ungauged rivers and streams, and those with only a few years of record, given that the physiographic and climatic features can be obtained.

2. PHYSIOGRAPHIC PARAMETERS

The following is a list of physiographic and climatic parameters, with a brief explanatory note on each, which were obtained for 16 drainage basins chosen in Nova Scotia. The data obtained was taken from a series of topographic maps at a scale of 1:50,000 for 14 of the 16 basins. The remaining two, Sharpe and Fraser Brooks, were too small to be accurately shown at a scale of 1:50,000, and so orthophoto maps at a scale of 1:10,000 were used.

For the basins big enough to be shown at a scale of 1:50,000, the basin boundaries used came from the Nova Scotia Drainage Atlas. The basins were simply traced from the maps in the atlas onto the working sheets. Fraser Brook and Sharpe Brook, however, had to be delineated without reference.

2.1 Total Length of Stream

All streams indicated by a solid blue line on the topographic maps within the boundary of the drainage area were measured. The sum total of all these streams gives the parameter, total length of stream. The measurement was done with an instrument known as a wheel, which was not a particularly accurate device with which to work, and made it difficult to maneuver along a stream with many bends. However, with careful manipulation and by measuring certain streams more than once, the obtained accuracy should be within acceptable limits.

When a lake was encountered in mid-stream, one of three things happened. If the lake was in mid-stream, the measurement was taken from where the stream entered the lake to where the stream exited the lake. If several streams ran into a lake, a reasonable assumption was made as to

where the streams would run if the lake was not there, and these paths were measured. If the lake encountered had a surface area of over 5 km^2, the perimeter of the lake was measured, and half this value was taken. When a stream began at a lake or pond, it was assumed that the stream began at the midpoint of the lake, and the measurement would begin at the halfway point along its longest dimension.

2.2 Average Slope of the Main Stem

The main stem was measured from the location of the hydrometric station on the main stream or river, along the main stream and into whichever tributaries gave the longest measurement of a continuous, non-intermittent watercourse. Because the origin of the main stem may be much steeper than the main body, and the end, due to deposits of sediments and so on, will be flatter than the main body, a distance of 15% of the main stem was left off at the origin, and a distance of 10% upstream from the station was left off when calculating the average slope. At these two points, the elevation of the river or stream was determined. Usually these points lay between two contour lines at an interval of 50 feet. A constant slope was assumed along the river between these lines, and this slope could be calculated by measuring the length of the river in this interval. By measuring the distance from either of the contour lines to either the 10% or 15% point, one could quickly calculate an approximate elevation of that point.

The average slope of the main stem was expressed as a percentage, taking the difference in elevation of the two points and dividing by the distance along the watercourse between these two points, then multiplying by 100.

If a large lake was encountered along the main stem, an assumption was made as to what path the river would take from the inlet of the lake to its outlet, instead of using a value of half the perimeter as explained previously when describing the total length of stream parameter.

2.3 Determination of Areas

Within the basin boundaries, the areas to be determined were: cleared, lake, swamp, and forested areas. The basin was first subdivided, using the light blue UTM grid on the topographic sheets. Each of the squares in this grid represents 1 km^2, and a group of four was used giving a basic block of 4 km^2. The blocks were numbered from the left bottom of a particular basin boundary. Where the boundary cut through a block, a partial block was measured.

In determining areas for the first two basins, River John and the Beaver River, a transparent grid, which was a 4 km^2 block divided into 100 little, equal sized squares, was used. One would simply overlay the grid on the block in question, and count the number of little squares occupied by either swamp, lake, or cleared land. Since the little squares represented an area of 0.04 km^2, these areas were obtained by multiplying the number of squares by 0.04 km^2. The forested areas were the difference between the total area and the sum of swamp, lake and cleared areas.

After these first two basins were complete, a Tamiya Planex 7 digital planimeter was used to measure the respective areas. The only drawback to this was the fact that the planimeter, when measuring at a scale of 1:50,000, only measures differences of 0.025 km^2. Therefore, if an area was small, say between 0.025 and 0.05 km^2, the planimeter

would only read one or the other. It was necessary in that case to measure small areas by using the grid overlay to get a more accurate value. These readings were tabulated according to block number and totalled to give the individual areas within the watershed boundary and the total area of the basin itself. This method was used for all watersheds except for Sharpe Brook and Fraser Brook which were measured on orthophoto maps at a scale of 1:10,000 which did not have the UTM grid printed on them. For these basins, a straight planimeter measurement was taken for each map.

Also included in the measurement of cleared area was the amount of cleared land allocated to roads and power lines running through forested parts of the basin. For roads, a cleared width of 66 feet was used to arrive at a figure which allowed 0.02 km^2 of cleared land per km of road. Similarly for power lines, a cleared width of 100 feet gave rise to a figure which allowed 0.03 km^2 of cleared land per km of power line. If more than one power line was indicated on the map, the amount of cleared per km was multiplied by the number of lines (i.e. 2 lines = 0.06 km^2/km).

The swamp area was measured by drawing an arbitrary boundary around the individual swamp symbols. If the swamp symbol occurred in a lake, this area wa considered to be lake area.

In many blocks, a large area, which would be measurable by planimeter, would have a small portion in an adjacent block. In the interest of ease of measurement, the small portion would be measured with the larger one. This is indicated on the maps by putting the number of the block with which it was measured beside the smaller piece.

2.4 Soils Index

Soil types present within the watershed boundaries were classified according to the SCS classifications for runoff potential. The soil types were classified A, B, C or D, with a 'D' type soil having the highest runoff potential and an 'A' type having the lowest. The maps used were those done through the Nova Scotia Soil Survey of the counties in the Province.

The method used was to take the soil types listed in the soil report which was included with the maps, read the descriptions of the individual soil, compare the description with the criteria given by the SCS and from this comparison decide whether a particular soil should be classified A, B, C or D. The soil map of the county in which a particular basin was located was then overlain by a transparency with a metric grid which was divided into smaller areas of 1 mm^2. The basin boundary was then delineated onto this transparency. Inside of the boundary, the area was divided up into A, B, C, D and peat type soils as shown on the soils maps. These areas were then measured by planimeter, or, if too small, by counting the individual mm^2 on the transparency. If the soil map was at the scale of 1:63,360, then 1 mm^2 = 0.004 km^2. If the soil map was at a scale of 1:126,720, then 1 mm^2 = 0.016 km^2. The individual areas were then totalled to give an indication of how much of each area was within the basin boundaries.

At the time of writing, there were no classifications for peat and swamp type soils, but the areas of each were determined so that, at a later date when a classification is decided upon, these soil types can be included. (My recommendation, since we are dealing with periods of low flow coupled with the fact that these soils occur in low-lying areas, would be that these soils be classified either A or B).

Problems associated with developing a soils index included the subjectivity of defining soil types as A, B, C or D. In most cases, but not all, the decision to classify a soil was not a clear cut one as soils, as described in the reports, may display characteristics included, for example, in both B and C descriptions. Topography was also an influencing factor. For instance, an A type soil on a steep slope would yield more runoff than an A type soil on an undulating plane. However, in most basins, the topography was generalized so small changes such as that above could not be accounted for. In some watersheds, soil types were identified along with changes in topography , and for the maps which had these classifications, an attempt was made to upgrade or downgrade soil types depending upon topography.

Another problem associated with the soil was the quality of the soils mapping. In Colchester, Pictou, Hants and Antigonish Counties, maps were available only at a scale of 1:126,720. Pictou also was mapped without contours, making delineation of any basin in this county merely approximate. Part of the Antigonish map also lacked contours. The Cape Breton Island maps had a scale of 1:84,480. At a scale of 1:126,720, the small basins in the above counties do not reflect the accuracy of the rest of the parameters in the study.

Inconsistent mapping was also a problem. Soil types would end at county borders, as that was the extent of mapping, but in the bordering county, the soil at the border would be a different type. For example, a Halifax type soil could border a Cumberland type soil, the only division being the county line. Also, lines dividing certain soil types within the counties would end at the county line and not continue as expected into the next county.

3. CLIMATIC FACTORS

3.1 Mean Annual Rainfall

A large 1:250,000 scale map of Nova Scotia was used to determine the approximate average annual rainfall in each of the basins chosen. Isolines of average yearly rainfall were plotted on the map, using data from Canadian Climate Normals, 1951-1980, Temperature and Precipitation, Atlantic Provinces. The basins used were then sketched in and the rainfall computed.

The isolines were plotted by placing rain stations and their values of mean annual rainfall at the appropriate points on the map and drawing the best isolines between stations. The lines were placed at intervals of 100 mm of rainfall except in the highlands of Cape Breton where the lines were placed at 200 mm intervals. In areas where a group of gauges had values close together, when one of them had a value which seemed out of line, the out of line value was disregarded.

In Cape Breton, there was a lack of rainfall information, so annual runoff values were used when plotting the isolines for the highlands.

To get the values of rainfall for the respective drainage basins, one of the following three methods was used:

(a) If the basin lay between two isolines with a gauge station contained within its boundaries, the value at the rain gauge station was used.

(b) If the entire watershed lay between two isolines with no rain station within its borders, then the rainfall value given to that basin is a value halfway between the values of the two lines.

(c) If an isoline cuts through the watershed, the area on each side of the line is expressed as a percentage of the entire basin. This percentage is then multiplied by the halfway value between the isoline which intersects the basin boundary and the next nearest line. This is repeated for both sides and the values are added to give a value of rainfall for the drainage basin.

4. WATERSHED NOTES

There were specific problems encountered which were unique to certain drainage basins. Below is a listing, by basin, of specific difficulties and their solutions.

01DG003 Beaver River	In blocks number 10, 11, 19, and 20, two hydro power lines appeared in a segment of cleared area. This cleared area was not counted, the lines were simply measured and given a value 0.06 km^2 of cleared area per km of line.
01D0001 River John	A telephone line was seen instead of a high tension line. Because the telephone line is smaller, a value of 0.02 km^2 of cleared land per km of line was used.
01FB003 Margaree River	This basin contained a large lake, Lake Ainslie, for which the main stem was only estimated. A hypothetical path for the stem was drawn through the lake and used for the main stem slope calculation. Also, the presence of this large lake means it was not a continuous average slope.
01E0001 St. Mary's River	Streams shown as indefinite along the West River-St. Mary's on Map 11E/8 are continued on Map 11E/1 as definite streams. Also, many lakes are joined to main tributaries with streams that are shown as indefinite. As a result, all indefinite streams which join lakes and those which are named have been measured and included with St. Mary's data, in case a decision may be made to use this information.
01ER001 Clam Harbour River	The stream system on map 11 F/12 including Clam Harbour Lake and Five Mile Lake is not shown as joining the Clam Harbour River. A hypothetical stream joining the two has been indicated on the map. The main stem and length of stream parameters have been calculated for both cases, one including Map 11 F/12 and one excluding it.
01EC001 Roseway River	A new type of land not previously encountered was found on Map 21 A/3 for this basin. In blocks numbered 38, 53 and 68, seasonally flooded land was present. Since the study deals with periods of low flow, the following assumptions were made. Blocks 38 and 68 were considered to be forested and block 53 was taken to be swamp.

01DD004 Sharpe Brook	All streams which were shown on the orthophoto maps were shown as indefinite. Therefore, the streams were measured and a decision should be made to take these measurements or ignore the parameters of total length of stream and main stem slope altogether.
01DH001 Fraser Brook	Streams shown on maps 11 E/6-T3 and 11 E/6-S4 are shown as indefinite. As a result, total length of stream and average slope of the main stem were computed with and without the streams on these maps.

5. COMPUTER APPLICATION

All data obtained has been put into a table on the Water Planning and Management account in the VAX computer in Moncton, New Brunswick. The table is in the RS-1 Files and is called NSLF.

Low flow data was obtained for seven drainage basins and these were plotted against the various parameters and the results are on the same account in the VAX in Moncton. Below is a list of the graphs resulting and their file identification.

File	Description (Low Flow vs)
LFAL(L)	Lake Area
LFAS(L)	Swamp Area
LFASAL(L)	Lake and Swamp Area
LFCA(L)	Cleared Area
LFDA(L)	Drainage Area
LFFA(L)	Forested Area
LFLS(L)	Length of Stream
LFMP(L)	Mean Precipitation
LFMSS(L)	Main Stem Slope
LFPC(L)	Percentage of Cleared
LFPF(L)	Percentage of Forest
LFPL(L)	Percentage of Lakes
LFPLS(L)	Percentage of Lakes and Swamps
LFPS(L)	Percentage of Swamps

The L in brackets means that when the graph was done, it was done on a log scale. These graphs are identified by taking the unbracketed letters and adding an L to them.

6. MAP REQUIREMENT LIST (1:50,000 Topographic Maps, 1:10,000 Orthophotos & Soil Maps)

Station	River	1:50,000 Topo Sheets	Soil Maps (counties)
01DG003	Beaver	11D/13	Halifax (West Sheet) Hants
01D0001	River John	11E/11, 11E/10	Colchester, Pictou
01FB003	S.W. Margaree	11K/3	Cape Breton (South West Sheet)
01EG002	Gold	21A/9, 21A/10, 21A/15, 21A/16	Lunenburg, Kings
01EN002	Liscomb	11E/1, 11E/2, 11E/8	Guysborough (West Sheet)
01EK001	Musquodoboit	11D/14, 11E/3, 11E/2	Halifax (Central, East Sheet), Colchester
01EF001	LaHave	21A/7, 21A/10, 21A/11 21A/15	Lunenburg, Kings, Annapolis
01E0001	St. Mary's	11E/1, 11E/2, 11E/7 11E/8, 11E/9, 11F/4 11F/5	Halifax, Guysborough, Pictou, Antigonish, Colchester
01DP004	Middle	11E/7	Pictou
01DR001	South	11E/8, 11E/9, 11F/5, 11F/12	Antigonish, Guysborough
01ER001	Clam Harbour	11F/5, 11F/6, 11F/11 11F/12	Guysborough
01EH003	East	11D/12, 11D/13	Halifax
01FB001	North East Margaree	11K/7, 11K/6, 11K/10 11K/11	Cape Breton
01EC001	Roseway River	21A/4, 21A/6, 21A/3 20P/14	Shelburne, Digby, Queens, Yarmouth

Station	River	1:10,000 Orthophotos
01DD004	Sharpe Brook	21H/02-T1, 21A/15-Z3
01DH003	Fraser Brook	11E/06-V2, 11E/06-W1 11E/06-T3. 11E/06-S4

TABLE 1

PHYSIOGRAPHIC PARAMETERS (NO ADJUSTMENT)

Station	River	Areas in km^2					Published Drainage Area (km^2)
		Cleared	Lake	Swamp	Forest	Total	
01DG003	Beaver	4.64	5.56	5.01	80.88	96.09	96.9
01D0001	River John	28.71	0.25	1.88	213.61	244.45	249.
01FB003	S.W. Margaree	33.04	57.72	3.31	261.98	356.05	357.
01EG002	Gold	10.66	17.95	8.17	333.92	370.70	370.
01EN002	Liscomb	1.39	24.00	29.28	339.11	393.78	389.
01EK001	Musquodoboit	73.10	23.68	26.97	551.25	674.99	650.
01EF001	LaHave	60.46	75.07	37.83	1076.31	1249.67	1250.
01E0001	St. Mary's	56.84	42.42	22.66	1222.47	1344.38	1350.
01DP004	Middle	11.09	0.24	0.16	82.53	94.03	92.2
01DR001	South	29.41	3.47	0.87	145.97	179.72	177.
01ER001	Clam Harbour	0.24	2.29	1.40	41.32	45.25	45.1
01EH003	East	2.23	2.05	0.29	22.36	26.93	26.9
01FB001	N.E. Margaree	16.37	1.20	8.30	336.48	362.36	368.
01EC001	Roseway	4.56	35.86	44.89	405.23	490.53	495.
01DD004	Sharpe	0.21	-	0.04	8.50	8.75	8.81
01DH001	Fraser	0.64	-	-	8.59	9.23	9.10

TABLE 2

PHYSIOGRAPHIC PARAMETERS (ADJUSTED)

(This is the data in NSLF in the VAX in Moncton)

Station	River	Length of Stream (km)	Main Stem Slope (%)	Areas in km^2			
				Cleared	Lake	Swamp	Forest
01DG003	Beaver	77.05	0.537	4.68*	5.61*	5.05*	81.56*
01D0001	River John	206.55	0.211	29.24*	0.25*	1.91*	217.59*
01FB003	S.W. Margaree	254.35	0.474	33.04	57.72	3.31	261.98
01EG002	Gold	191.43	0.438	10.66	17.95	8.17	333.92
01EN002	Liscomb	387.65	0.186	1.37*	23.69*	28.90*	335.06*
01EK001	Musquodoboit	442.28	0.102	70.39*	22.80*	25.97*	530.84*
01EF001	LaHave	762.40	0.294	60.46	75.07	37.83	1076.31
01E0001	St. Mary's	753.38	0.191	57.07*	42.60*	22.75*	1227.58*
01DP004	Middle	34.70	0.848	10.87*	0.24*	0.16*	80.93*
01DR001	South	98.28	0.361	28.96*	3.42*	0.85*	143.77*
01ER001	Clam Harbour	42.65**	0.424**	0.24	2.29	1.40	41.32
01EH003	East	20.63	0.655	2.23	2.05	0.29	22.36
01FB001	N.E. Margaree	201.20	0.785	16.63*	1.22*	8.43*	341.72*
01EC001	Roseway	305.88	0.149	4.60*	36.18*	45.29*	408.92*
01DD004	Sharpe	6.56**	2.830**	0.21	0.00	0.04	8.50
01DH001	Fraser	1.83**	0.739**	0.63*	0.00	0.00	8.47*

* Areas have been adjusted

** Indicates a problem with the stream data as previously explained.

TABLE 3

PHYSIOGRAPHIC PARAMETERS (PERCENTAGES)

(Areas expressed as a percentage of total drainage area as found in Table HSLF in the VAX in Moncton)

Station	River	Areas in Percentages					One day ten year available low flows ($m^3/s/km^2$)
		Cleared	Lake	Swamp	Lake & Swamp	Forest	
01DG003	Beaver	4.83	5.79	5.21	11.00	84.17	0.000059
01D0001	River John	11.74	0.10	0.77	0.87	87.38	-
01FB003	S.W. Margaree	9.28	16.21	0.93	17.14	73.58	0.003126
01EG002	Gold	2.88	4.84	2.20	7.04	90.08	-
01EN002	Liscomb	0.35	6.09	7.43	13.52	86.13	-
01EK001	Musquodoboit	10.83	3.51	3.99	7.50	81.67	-
01EF001	LaHave	4.84	6.01	3.03	9.04	86.13	0.000284
01E0001	St. Mary's	4.23	3.16	1.69	4.85	90.93	0.000308
01DP004	Middle	11.79	0.26	0.17	0.42	87.78	-
01DR001	South	16.60	1.93	0.48	2.41	81.22	-
01ER001	Clam Harbour	0.53	5.06	3.09	8.15	91.32	-
01EH003	East	8.27	7.61	1.08	8.69	83.04	0.000263
01FB001	N.E. Margaree	4.52	0.33	2.29	2.62	92.86	0.005470
01EC001	Roseway	0.93	7.31	9.15	16.46	82.61	0.000969
01DD004	Sharpe	2.35	-	0.45	0.45	97.21	-
01DH001	Fraser	6.92	0.00	0.00	0.00	93.08	-

TABLE 4

MEAN ANNUAL PRECIPITATION

Station	River	Average Yearly Precipitation (mm)
01DG003	Beaver	1450
01D@001	River John	1062
01FB003	S.W. Margaree	1450
01EG002	Gold	1445
01EN002	Liscomb	1450
01EK001	Musquodoboit	1362
01EF001	LaHave	1414
01E@001	St. Mary's	1399
01DP004	Middle	1250
01DR001	South	1355
01ER001	Clam Harbour	1350
01EH003	East	1350
01FB001	N.E. Margaree	1605
01EC001	Roseway	1450
01DD004	Sharpe	1319
01DH001	Fraser	1244

TABLE 5

SOILS DATA

Station	River	A Type	B Type	C Type	D Type	Peat	Swamp	S. Peat
01DG003	Beaver	0.20	15.07	72.02	-	1.735	0.07	-
01D0001	River John	84.04	41.12	71.17	45.61	4.56	-	-
01FB003	S.W. Margaree	10.00	0.36	1.43	274.70	5.83	-	-
01EG002	Gold	2.70	168.96	127.08	41.19	0.61	6.44	-
01EN002	Liscomb	0.01	213.04	45.81	81.42	25.14	-	-
01EK001	Musquodoboit	18.07	184.14	186.49	241.62	16.87	-	-
01EF001	LaHave	13.97	687.21	349.26	62.74	28.97	14.40	-
01E0001	St. Mary's	46.02	838.67	358.56	28.33	16.49	-	-
01DP004	Middle	4.67	67.70	19.32	0.29	0.59	-	-
01DR001	South	3.36	34.03	97.88	38.06	1.72	-	-
01ER001	Clam Harbour	-	-	42.20	0.34	0.79	-	-
01EH003	East	-	20.15	1.13	0.36	0.11	-	-
01FB001	N.E. Margaree	19.27	-	-	333.91	6.08	-	-
01EC001	Roseway	9.24	373.59	32.16	0.28	15.89	-	11.80
01DD004	Sharpe*							
01DH001	Fraser*							

* Fraser Brook and Sharpe Brook were not done because the soil maps available were of too small a scale to make accurate measurements possible.